

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Tatsuya Matsunaga, et al.
Title: VISUAL DISPLACEMENT
SENSOR
Appl. No.: Unassigned
Filing Date: 09/26/2001
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Art Unit: Unassigned

PRELIMINARY AMENDMENT

Commissioner for Patents
Box PATENT APPLICATION
Washington, D.C. 20231

Sir:

Prior to examination of the above-application, Applicants respectfully request that the following amendments be entered into the application:

In the Claims:

Please cancel claims 66 and 67 and in accordance with 37 CFR §1.121, please substitute for original claims 5, 6, and 30, the following rewritten versions of the same claims, as amended. The changes are shown explicitly in the attached "Versions With Markings to Show Changes Made."

5. (Amended) A visual displacement sensor according to claim 1, wherein the measurement point coordinate determining means determines one or more than one measurement point according to an image extracted from the image captured by the two-dimensional imaging device by masking the area other than the defined one or more than one measurement object range.

6. (Amended) A visual displacement sensor according to claim 1, wherein the measurement point coordinate determining means provisionally determines one or more than one measurement point according to an entire image captured by the two-

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dimensional imaging device, and finally determines one or more than one measurement point by comparing the provisionally determined one or more than one measurement point with a counterpart in the defined one or more than one measurement object range.

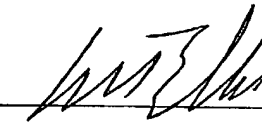
30. (Amended) A visual displacement sensor according to claim 16, further comprising a range automatic tracking means for tracking a change in a measurement displacement with respect to a reference surface of a measurement object and moving at least one measurement object range in a direction of displacement measurement direction.

REMARKS

Applicants respectfully request that the foregoing amendments to Claims 5, 6, and 30 be entered in order to avoid this application incurring a surcharge for the presence of one or more multiple dependent claims.

Respectfully submitted,

By



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VERSION WITH MARKINGS TO SHOW CHANGES

5. (Amended) A visual displacement sensor according to [any one of claims 1 to 4] claim 1, wherein the measurement point coordinate determining means determines one or more than one measurement point according to an image extracted from the image captured by the two-dimensional imaging device by masking the area other than the defined one or more than one measurement object range.

6. (Amended) A visual displacement sensor according to [any one of claims 1 to 4] claim 1, wherein the measurement point coordinate determining means provisionally determines one or more than one measurement point according to an entire image captured by the two-dimensional imaging device, and finally determines one or more than one measurement point by comparing the provisionally determined one or more than one measurement point with a counterpart in the defined one or more than one measurement object range.

30. (Amended) A visual displacement sensor according to [any one of claims 16 to 29] claim 16, further comprising a range automatic tracking means for tracking a change in a measurement displacement with respect to a reference surface of a measurement object and moving at least one measurement object range in a direction of displacement measurement direction.

CLAIMS

1. A visual displacement sensor, comprising:
- 5 a light emitting device for impinging a line beam onto an object to be measured at a prescribed angle;
- a two-dimensional imaging device for monitoring the object to be measured, on which the line beam is impinged, from a different angle;
- measurement object range defining means for defining one or more than one measurement object range within a field of view of the two-dimensional imaging
- 10 device;
- measurement point coordinate determining means for determining one or more than one measurement point coordinate contained in the defined measurement object range according to an image captured by the two-dimensional imaging device; and
- 15 displacement measuring means for measuring a desired displacement according to the determined one or more than one measurement point coordinate.
2. A visual displacement sensor according to claim 1, wherein the one or more than one measurement object range is defined by the measurement object range defining means with respect to a position and length in a direction of displace
- 20 measurement in the field of view of the two-dimensional imaging device.
3. A visual displacement sensor according to claim 1, wherein the one or more than one measurement object range is defined by the measurement object range defining means with respect to a position and length in a direction perpendicular to a direction of displace measurement in the field of view of the two-dimensional
- 25 imaging device.

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4. A visual displacement sensor according to claim 1, wherein the one or more than one measurement object range is defined by the measurement object range defining means with respect to a position and length both in a direction of displacement measurement and a direction perpendicular to a direction of displacement measurement in the field of view of the two-dimensional imaging device.

5. A visual displacement sensor according to any one of claims 1 to 4, wherein the measurement point coordinate determining means determines one or more than one measurement point according to an image extracted from the image captured by the two-dimensional imaging device by masking the area other than the defined one or more than one measurement object range.

6. A visual displacement sensor according to any one of claims 1 to 4, wherein the measurement point coordinate determining means provisionally determines one or more than one measurement point according to an entire image captured by the two-dimensional imaging device, and finally determines one or more than one measurement point by comparing the provisionally determined one or more than one measurement point with a counterpart in the defined one or more than one measurement object range.

7. A visual displacement sensor according to claim 1, further comprising monitor image editing means for displaying information on a state of the raw image captured by the two-dimensional imaging device on an image monitor screen.

8. A visual displacement sensor according to claim 7, wherein the information on a state of the raw image comprises the raw image itself and/or a line bright waveform corresponding to the raw image.

9. A visual displacement sensor according to claim 1, further comprising monitor image editing means for displaying information on a state of the masked

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image extracted from the raw image captured by the two-dimensional imaging device by masking a part thereof other than the defined measurement object range on an image monitor screen.

10. A visual displacement sensor according to claim 9, wherein the information
5 on a state of the masked image comprises the masked image itself and/or a line bright waveform corresponding to the masked image.

11. A visual displacement sensor according to claim 1, further comprising
monitor image editing means for displaying information corresponding to the
measurement object range defined in the field of view of the two-dimensional
10 imaging device on an image monitor screen.

12. A visual displacement sensor according to claim 11, wherein the
information corresponding to the measurement object range comprises a boundary
position and/or a value indicating a boundary of the measurement object range on the
raw image or masked image.

13. A visual displacement sensor according to claim 1, further comprising
monitor image editing means for displaying information corresponding to the
measurement point coordinate determined in the field of view of the two-dimensional
15 imaging device on an image monitor screen.

14. A visual displacement sensor according to claim 13, wherein the
20 information corresponding to the measurement point coordinate comprises a value
indicating a measurement point coordinate position and/or measurement point
coordinate on the raw image or masked image.

15. A visual displacement sensor according to claim 1, further comprising a
graphical user interface (GUI) for enabling the defining, changing and canceling of
25 the measurement object range in the field of view of the two-dimensional imaging

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device with an operation on an image monitor screen.

16. A visual displacement sensor, comprising:

a light emitting device for impinging a line beam onto an object to be measured at a prescribed angle;

5 a two-dimensional imaging device for monitoring the object to be measured on which the line beam is impinged from a different angle;

measurement object range defining means for defining more than one measurement object range having a designated position and length in the direction of displacement measurement within a field of view of the two-dimensional imaging
10 device;

measurement point coordinate determining means having a gradation adjusting function for determining one or more than one measurement point coordinate contained in the defined measurement object range according to an image captured by the two-dimensional imaging device and adjusting at least one line beam
15 light image gradation if the corresponding measurement object range contains one or more line beam light image; and

displacement measuring means for measuring a desired displacement according to the determined one or more than one measurement point coordinate.

17. A visual displacement sensor according to claim 16, wherein the
20 measurement point coordinate determining means having a gradation adjusting function comprises:

masked image generating means for generating a masked image by masking the part of the raw image captured by the two-dimensional imaging device other than the defined measurement object range; and

25 measurement point coordinate determining means for adjusting the light

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image gradation of the at least one line beam light image to a value suitable for measurement and determining a measurement point coordinate by changing an image capturing condition of the two-dimensional imaging device when the corresponding masked image contains at least one line beam light image.

- 5 18. A visual displacement sensor according to claim 16, wherein the measurement point coordinate determining means having a gradation adjusting function comprises:

provisional measurement point coordinate determining means for adjusting the light image gradation of the at least one line beam light image to a value suitable
10 for measurement provisionally and determining a measurement point coordinate by changing an image capturing condition of the two-dimensional imaging device when the raw image captured by the two-dimensional imaging device contains at least one line beam light image; and

final measurement point coordinate determining means for finally
15 determining a measurement point coordinate by comparing the provisionally determined measurement point coordinate with the defined measurement object range.

19. A visual displacement sensor according to claim 16, further comprising monitor image editing means for displaying information corresponding to a state of
20 the raw image captured by the two-dimensional imaging device on an image monitor screen.

20. A visual displacement sensor according to claim 19, wherein the information on a state of the raw image comprises the raw image itself and/or a line bright waveform corresponding to the raw image.

- 25 21. A visual displacement sensor according to claim 17, further comprising

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monitor image editing means for displaying information on a state of the masked image extracted from the raw image captured by the two-dimensional imaging device by masking a part thereof other than the defined measurement object range on an image monitor screen.

- 5 22. A visual displacement sensor according to claim 21, wherein the information on a state of the masked image comprises the masked image itself and/or a line bright waveform corresponding to the masked image.

23. A visual displacement sensor according to claim 16, further comprising monitor image editing means for displaying information corresponding to the measurement object range defined in the field of view of the two-dimensional imaging device on the image monitor screen.
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24. A visual displacement sensor according to claim 23, wherein the information corresponding to the measurement object range comprises a boundary position and/or a value indicating a boundary of the measurement object range on the raw image or masked image.
- 15

25. A visual displacement sensor according to claim 16, further comprising monitor image editing means for displaying information corresponding to the measurement point coordinate determined in the field of view of the two-dimensional imaging device on an image monitor screen.

- 20 26. A visual displacement sensor according to claim 25, wherein the information corresponding to the measurement point coordinate comprises a value indicating a measurement point coordinate position and/or measurement point coordinate on the raw image or masked image.

27. A visual displacement sensor according to claim 16, further comprising monitor image editing means for displaying information corresponding to an image
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capturing condition for each measurement object range used for determining a measurement point coordinate on an image monitor screen.

28. A visual displacement sensor according to claim 27, wherein the information corresponding to an image capturing condition comprises a value or
5 graphic diagram indicating a sensitivity for image capturing.

29. A visual displacement sensor according to claim 16, further comprising a graphical user interface (GUI) for enabling the defining, changing and canceling of the measurement object range in the field of view of the two-dimensional imaging device with an operation on an image monitor screen.

10 30. A visual displacement sensor according to any one of claims 16 to 29, further comprising a range automatic tracking means for tracking a change in a measurement displacement with respect to a reference surface of a measurement object and moving at least one measurement object range in a direction of displacement measurement direction.

15 31. A visual displacement sensor according to claim 30, wherein the range automatic tracking means is adapted to move a measurement object range containing a line beam image from a surface different from the reference surface of the measurement object.

32. A visual displacement sensor, comprising:

20 a light emitting device for impinging a line beam onto an object to be measured at a prescribed angle;

a two-dimensional imaging device for monitoring the object to be measured on which the line beam is impinged from a different angle;

measurement object range defining means for defining more than one
25 measurement object range having a designated position and length in a direction

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perpendicular to the direction of displacement measurement within a field of view of the two-dimensional imaging device;

measurement point coordinate determining means having a gradation adjusting function for determining one or more than one measurement point coordinate contained in the defined measurement object range according to an image captured by the two-dimensional imaging device and adjusting at least one line beam light image gradation if the corresponding measurement object range contains one or more line beam light image; and

displacement measuring means for measuring a desired displacement according to the determined one or more than one measurement point coordinate.

33. A visual displacement sensor according to claim 32, wherein the measurement point coordinate determining means having a gradation adjusting function comprises:

masked image generating means for generating a masked image by masking the part of the raw image captured by the two-dimensional imaging device other than the defined measurement object range; and

measurement point coordinate determining means for adjusting the light image gradation of the at least one line beam light image to a value suitable for measurement and determining a measurement point coordinate by changing an image capturing condition of the two-dimensional imaging device when the corresponding masked image contains at least one line beam light image.

34. A visual displacement sensor according to claim 32, wherein the measurement point coordinate determining means having a gradation adjusting function comprises:

provisional measurement point coordinate determining means for adjusting

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the light image gradation of the at least one line beam light image to a value suitable for measurement and provisionally determining a measurement point coordinate by changing an image capturing condition of the two-dimensional imaging device when the raw image captured by the two-dimensional imaging device contains at least one

5 line beam light image; and

final measurement point coordinate determining means for finally determining a measurement point coordinate by comparing the provisionally determined measurement point coordinate with the defined measurement object range.

10 35. A visual displacement sensor according to claim 32, further comprising monitor image editing means for displaying information corresponding to a state of the raw image captured by the two-dimensional imaging device on an image monitor screen.

36. A visual displacement sensor according to claim 35, wherein the
15 information on a state of the raw image comprises the raw image itself and/or a line bright waveform corresponding to the raw image.

37. A visual displacement sensor according to claim 33, further comprising monitor image editing means for displaying information on a state of the masked image extracted from the raw image captured by the two-dimensional imaging device
20 by masking a part thereof other than the defined measurement object range on an image monitor screen.

38. A visual displacement sensor according to claim 37, wherein the information on a state of the masked image comprises the masked image itself and/or a line bright waveform corresponding to the masked image.

25 39. A visual displacement sensor according to claim 32, further comprising

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monitor image editing means for displaying information corresponding to the measurement object range defined in the field of view of the two-dimensional imaging device on an image monitor screen.

40. A visual displacement sensor according to claim 39, wherein the
5 information corresponding to the measurement object range comprises a boundary position and/or a value indicating a boundary of the measurement object range on the raw image or masked image.

41. A visual displacement sensor according to claim 32, further comprising
10 monitor image editing means for displaying information corresponding to the measurement point coordinate determined in the field of view of the two-dimensional imaging device on an image monitor screen.

42. A visual displacement sensor according to claim 41, wherein the
15 information corresponding to the measurement point coordinate comprises a value indicating a measurement point coordinate position and/or measurement point coordinate on the raw image or masked image.

43. A visual displacement sensor according to claim 32, further comprising
monitor image editing means for displaying information corresponding to an image capturing condition for each measurement object range used for determining a measurement point coordinate on an image monitor screen.

20 44. A visual displacement sensor according to claim 43, wherein the information corresponding to an image capturing condition comprises a value or graphic diagram indicating a sensitivity for image capturing.

45. A visual displacement sensor according to claim 32, further comprising a graphical user interface (GUI) for enabling the defining, changing and canceling of
25 the measurement object range in the field of view of the two-dimensional imaging

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device with an operation on an image monitor screen.

46. A visual displacement sensor, comprising:

a light emitting device for impinging a line beam onto an object to be measured at a prescribed angle;

5 a two-dimensional imaging device for monitoring the object to be measured on which the line beam is impinged from a different angle;

measurement object range defining means for defining more than one measurement object range having a designated position and length in both the direction of displacement measurement and a direction perpendicular to the direction
10 of displacement measurement with a two-dimensional expanse within a field of view of the two-dimensional imaging device;

measurement point coordinate determining means having a gradation adjusting function for determining one or more than one measurement point coordinate by taking into account the defined measurement object range according to
15 an image captured by the two-dimensional imaging device and adjusting the gradation of each line beam light image; and

displacement measuring means for measuring a desired displacement according to the determined one or more than one measurement point coordinate.

47. A visual displacement sensor according to claim 46, wherein the
20 measurement point coordinate determining means having a range determining function comprises:

masked image generating means for generating a masked image by masking the part of the raw image captured by the two-dimensional imaging device other than the defined measurement object range; and

25 measurement point coordinate determining means for adjusting the light

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image gradation of the at least one line beam light image to a value suitable for measurement and determining a measurement point coordinate by changing an image capturing condition of the two-dimensional imaging device for each line beam light image in the masked image.

- 5 48. A visual displacement sensor according to claim 46, wherein the measurement point coordinate determining means having a range determining function comprises:

provisional measurement point coordinate determining means for adjusting the light image gradation of the at least one line beam light image to a value suitable for measurement and provisionally determining a measurement point coordinate by changing an image capturing condition of the two-dimensional imaging device for each line beam image contained in the raw image captured by the two-dimensional imaging device; and

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final measurement point coordinate determining means for finally determining a measurement point coordinate by comparing the provisionally determined measurement point coordinate with the defined measurement object range.

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49. A visual displacement sensor according to claim 46, further comprising monitor image editing means for displaying information corresponding to a state of the raw image captured by the two-dimensional imaging device on an image monitor screen.
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50. A visual displacement sensor according to claim 49, wherein the information on a state of the raw image comprises the raw image itself and/or a line bright waveform corresponding to the raw image.

- 25 51. A visual displacement sensor according to claim 47, further comprising

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monitor image editing means for displaying information on a state of the masked image extracted from the raw image captured by the two-dimensional imaging device by masking a part thereof other than the defined measurement object range on an image monitor screen.

5 52. A visual displacement sensor according to claim 51, wherein the information on a state of the masked image comprises the masked image itself and/or a line bright waveform corresponding to the masked image.

53. A visual displacement sensor according to claim 46, further comprising monitor image editing means for displaying information corresponding to the
10 measurement object range defined in the field of view of the two-dimensional imaging device on an image monitor screen.

54. A visual displacement sensor according to claim 53, wherein the information corresponding to the measurement object range comprises a boundary position and/or a value indicating a boundary of the measurement object range on the
15 raw image or masked image.

55. A visual displacement sensor according to claim 46, further comprising monitor image editing means for displaying information corresponding to the measurement point coordinate determined in the field of view of the two-dimensional imaging device on the image monitor screen.

20 56. A visual displacement sensor according to claim 55, wherein the information corresponding to the measurement point coordinate consists of a value indicating a measurement point coordinate position and/or measurement point coordinate on the raw image or masked image.

57. A visual displacement sensor according to claim 46, further comprising
25 monitor image editing means for displaying information corresponding to an image

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capturing condition for each measurement object range used for determining a measurement point coordinate on an image monitor screen.

58. A visual displacement sensor according to claim 57, wherein the information corresponding to an image capturing condition comprises a value or
5 graphic diagram indicating a sensitivity for image capturing.

59. A visual displacement sensor according to claim 46, further comprising a graphical user interface (GUI) for enabling the defining, changing and canceling of the measurement object range in the field of view of the two-dimensional imaging device with an operation on an image monitor screen.

10 60. A visual displacement sensor, comprising:

a light emitting device for impinging a line beam onto an object to be measured at a prescribed angle;

a two-dimensional imaging device for monitoring the object to be measured, on which the line beam is impinged, from a different angle;

15 measurement object range defining means for defining one or more than one measurement object range within a field of view of the two-dimensional imaging device;

measurement point coordinate determining means for determining one or more than one measurement point coordinate contained in the defined measurement
20 object range according to an image captured by the two-dimensional imaging device, displacement measuring means for measuring a desired displacement according to the determined one or more than one measurement point coordinate; and

defined range moving means for moving at least one of the one or more than one measurement object range that are defined according to information derived
25 from an image captured by the two-dimensional imaging device.

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61. A visual displacement sensor according to claim 60, wherein, when it is determined that a reference surface has moved according to the image captured by the two-dimensional imaging device, the defined range moving means moves the measurement object range corresponding to a surface forming a pair with the reference surface in the direction of displacement measurement following the movement of the reference surface.

62. A visual displacement sensor according to claim 61, wherein the determination that the reference surface has moved is made in response to a change in the displacement measured by using the measurement object range defined in advance according to the reference surface.

63. A visual displacement sensor according to claim 60, wherein, when it is determined that a boundary line of a step on the measurement object has moved according to the image captured by the two-dimensional imaging device, the defined range moving means moves a pair of measurement object ranges defined on either side of the step boundary line in a direction perpendicular to the direction of displacement measurement following the movement of the step boundary line.

64. A visual displacement sensor according to claim 62, wherein the determination that the step boundary line has moved is made in response to a movement of an intersection between the measured displacement along the length of the line beam and a prescribed displacement threshold value in a direction perpendicular to the direction of displacement measurement.

65. A visual displacement sensor according to claim 64, wherein the prescribed displacement threshold value is defined so as to follow the measured value of the reference step surface forming the step.

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